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Injury-specific predictors of posttraumatic stress disorder

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ABSTRACT

Objective: Posttraumatic stress disorder (PTSD) is an important source of morbidity in military personnel, but its relationship with characteristics of battle injury has not been well defined. The aim of this study was to characterise the relationship between injury-related factors and PTSD among a population of battle injuries.

Patients and methods: A total of 831 American military personnel injured during combat between September 2004 and February 2005 composed the study population. Patients were followed through November 2006 for diagnosis of PTSD (ICD-9 309.81) or any mental health outcome (ICD-9 290-319).

Results: During the follow-up period, 31.3% of patients received any type of mental health diagnosis and 17.0% received a PTSD diagnosis. Compared with minor injuries those with moderate (odds ratio [OR], 2.37; 95% confidence interval [CI], 1.61–3.48), serious (OR, 4.07; 95% CI, 2.55–6.50), and severe (OR, 5.22; 95% CI, 2.74–9.96) injuries were at greater risk of being diagnosed with any mental health outcome. Similar results were found for serious (OR, 3.03; 95% CI, 1.81–5.08) and severe (OR, 3.21; 95% CI, 1.62–6.33) injuries with PTSD diagnosis. Those with gunshot wounds were at greater risk of any mental health diagnosis, but not PTSD, in comparison with other mechanisms of injury (OR 2.07; 95% CI, 1.35, 3.19). Diastolic blood pressure measured postinjury was associated with any mental health outcome, and the effect was modified by injury severity.

Conclusions: Injury severity was a significant predictor of any mental health diagnosis and PTSD diagnosis. Gunshot wounds and diastolic blood pressure were significant predictors of any mental health diagnosis, but not PTSD. Further studies are needed to replicate these results and elucidate potential mechanisms for these associations.

Introduction

Posttraumatic stress disorder (PTSD), an anxiety disorder characterised by symptoms of avoidance, re-experiencing, and hyperarousal, has an estimated lifetime prevalence of 10% among women and 5% among men in the United States.[16,48] Physical injury has been identified as a risk factor for PTSD in both military combat populations[27,28,35,47] and civilians surviving disasters.[1,22,24,30,31,52,55] Postinjury physiological measures, including heart rate and blood pressure, as well as injury-related variables, such as severity, location, and mechanism, may also be related to subsequent development of PTSD.

Multiple studies have shown that elevated heart rate following trauma is a predisposing factor for development of PTSD.[7–9,32,45,49,50,56] Heart rate was identified as a significant predictor of PTSD when measured immediately following trauma and 1 week after, though not at 1 month postinjury.[9,50] Other studies, however, have failed to confirm this relationship.[4,10] In one study, a significant inverse association between posttrauma heart rate and PTSD was identified.[4] To our knowledge, the relationship between posttrauma heart rate and PTSD has not been examined within a military population.

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Additionally, evidence is mixed on the relationship between objective injury severity and PTSD.[12,5,6,12–15,17,26,29,33,34,43,44,57] Some studies have shown a positive association with PTSD,[5,17,26,43] but multiple other studies have failed to replicate this result,[6,12,14,15,29,34,46,57] with one showing a negative association.[13] A recent study by Grieger et al. of severely injured veterans of Operation Iraqi Freedom (OIF) identified an association between subjective injury severity and PTSD.[23]

Other aspects of injury (e.g., injury mechanism and location) have not been thoroughly examined in the literature. Some civilian studies have identified associations between PTSD and injury mechanism,[21,29,51] and PTSD and facial location among burn patients.[18,38]

The purpose of this study was to characterise the relationship between injury-related factors and PTSD among a population of battle injuries. Posttrauma heart rate and blood pressure, as well as injury mechanism, location, and severity, were examined. This research was conducted in compliance with all applicable United States federal regulations governing the protection of human subjects in research and was approved by the Institutional Review Board of the Naval Health Research Center, San Diego, CA, United States (Protocol NHRC.2007.0004).

Patients and methods

Study population

The study population was comprised of 831 male injured personnel. Patients were identified from the United States Navy-Marine Corps Combat Trauma Registry Expeditionary Medical Encounter Database (Navy-MC CTR EMED), which is a deployment health database maintained by the Naval Health Research Center (NHRC) consisting of documented clinical encounters of deployed military personnel. Records are obtained for battle injury, nonbattle injury, disease, and psychiatric and routine sick-call encounters.[19,54] Eligible personnel in this study were American OIF combatants who presented to U.S. Navy-Marine Corps forward-deployed medical treatment facilities for battle injury during the 6-month period from September 2004 to February 2005. Precise date of injury was not indicated for all personnel, therefore date of arrival for medical care was used as a proxy for injury date. After excluding females because of low representation (less than 1%) and 38 individuals who died as a result of their wounds, 881 participants were matched against the Career History Archival Medical and Personnel System (CHAMPS). A database maintained by NHRC, CHAMPS contains demographic, career, and medical information on all military members on active duty in the U.S. Armed Services since 1973 (see Gunderson et al., for a detailed description of CHAMPS).[25] A total of 841 eligible injured personnel (95.5%) had a matching record in CHAMPS. Ten individuals were excluded because of evidence of military discharge less than 90 days into the follow-up period.

Measures

Data for the independent physiological variables were abstracted from the Navy-MC CTR EMED clinical record. Heart rate, measured in beats per minute (bpm), and diastolic and systolic blood pressure (DBP, SBP), measured in millimetres of mercury (mm Hg), were ascertained following injury. No information existed regarding the method of measurement, whether it was manual or equipment-based. In the case that multiple heart rate and blood pressure measurements were taken, only the first recorded measurements were used. Thirty-four patients had evidence of physiological measures taken more than 24 h postinjury and were excluded from analysis of these measures. In addition, approximately 10% of data were missing for physiological measures.

Injury severity was first described using the Abbreviated Injury Scale (AIS); a composite ISS was then calculated by on-site NHRC researchers.[2,20] Injury mechanism (e.g., improvised explosive device [IED], gunshot wound) was indicated on the Navy-MC CTR EMED clinical record. Facial injury location was indicated by the AIS code.

Two different methods were used to define cases: (1) diagnosis of any mental health outcome, and (2) diagnosis of PTSD. Diagnoses in the form of *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes were abstracted from CHAMPS. The CHAMPS database was updated up through November 2006, as such there were approximately 22–27 months of follow-up time, although some participants were discharged from the military over the course of the follow-up period (CHAMPS does not monitor personnel following military discharge). Those discharged without a mental health diagnosis were assumed to not have developed the outcome.

A diagnosis of PTSD was indicated by ICD-9 code 309.81 and a diagnosis of any mental health outcome was indicated by an ICD-9 code in the range of 290–319, excluding 305.10 (tobacco addiction). For diagnosis of PTSD, the date of diagnosis must have been at least 1 month postinjury as per the definition of PTSD that requires symptoms to persist for at least 1 month; any PTSD diagnosis less than 1 month postinjury was treated as a previous mental health diagnosis.

Other covariates were assessed for adjustment purposes. Age, military rank and service were abstracted from the Navy-MC CTR EMED clinical record for all persons in the study population and marital status was abstracted from CHAMPS. Intelligence, which is related to development of PTSD,[37] was measured with the Armed Forces Qualification Test (AFQT) score abstracted from CHAMPS.[53] Previous mental health diagnoses have also been identified as a risk factor for PTSD development, and were ascertained from CHAMPS.[39] Presence of an ICD-9 code between 290 and 319 (excluding 305.10) at any time (whilst in the military) since January 1, 2000 and prior to the date of injury was considered a previous mental health diagnosis.

Data analysis

Heart rate was assessed as a continuous variable in descriptive analysis and then categorised for statistical modelling purposes. Based on previous literature, a cut-off of at least 95 bpm was used to create a dichotomous variable of elevated versus nonelevated heart rate.[8,58] Injury location was dichotomised into either facial or nonfacial injury. Mechanism of injury was categorised into a 7-level variable for descriptive analysis, then collapsed into a 3-level variable for modelling purposes, to ensure an adequate number of responses in each level; the two mechanism categories of interest, IEDs and gunshot wounds, were used as two of the levels and the reference level was all other mechanisms. ISS (range 1–75) was categorised as per previous literature, and groupings for this study were minor injury (ISS 1–3), moderate injury (ISS 4–8), serious injury (ISS 9–15), and severe injury (ISS 16 or higher).[2,11,36]

All statistical analyses were performed in SAS version 9.1 software (Cary, NC). Differences across groups by outcome status, any mental health outcome and PTSD diagnosis, were tested using chi-square and Fisher's exact tests for categorical variables and two-sample *t* tests for continuous variables. Regression analysis was conducted separately for each of the mental health outcome classifications. Additionally, physiological and injury-specific measures were analysed separately so as not to lose statistical power in the injury-specific model because of missing physiological data. Logistic regression analysis was conducted for all potential predictor variables individually, with only age in the model. Any predictor variable meeting a significance level of .10 was advanced to further multivariate analysis; any physiological

variable meeting this criterion, however, was reanalysed adjusting for injury severity. Interaction was tested between physiological variables and injury severity. After placing predictors together in a logistic regression model, the significance level for the final model was ≤ 0.05. Covariates were assessed for potential confounding using criterion of a 20% change in odds ratio. Adjusted odds ratios, confidence intervals, and *p* values were reported for all associations. Multiple sensitivity analyses were conducted to assess the impact of loss to follow-up via military discharge; in one case it was assumed all discharges developed the outcome, and in another it was assumed a 50% random sample of the discharges developed the outcome. Sensitivity analyses were conducted separately for first-year discharges and total discharges.

Results

There were a total of 831 patients in this study. Age ranged between 18 and 54 years (mean, 24.1 $\pm$ 5.3 years). More than three quarters (76.7%) of the participants were Marine Corps personnel, compared with 19.0% in the Army and 4.3% in other services or unknown. A large majority (84.1%) of the participants were of ranks E1–E5 (junior enlisted).

Seventeen percent (n = 141) of all patients received a diagnosis of PTSD at sometime during the follow-up period. When examining any mental health outcome, 31.3% (n = 260) received a mental health diagnosis during the follow-up period. Median time until any mental health diagnosis was 125.5 days, with a range of 1–729 days.

Of the 831 patients, 64.7% had injuries that were classified as minor, 18.7% as moderate, 11.2% as serious, and 5.4% as severe. The largest proportion of injuries (41.3%) was caused by IEDs, followed by other blast injuries (19.0%), and gunshot wounds (17.6%). Approximately 42% of all injuries involved a facial injury. Among the total study population, the postinjury physiological measures of heart rate, systolic blood pressure, and diastolic blood pressure were 86.5 $\pm$ 18.6 beats per minute, 128.2 $\pm$ 16.3 mm Hg, and 72.2 $\pm$ 13.2 mm Hg, respectively.

Table 1 presents the prevalence of demographic, injury-specific, and physiological variables by case status. Because multiple outcome definitions were used, descriptive statistics are shown for the two individual study populations: (1) any mental health diagnosis versus no mental health diagnosis, and (2) PTSD diagnosis versus no PTSD diagnosis.

Any mental health diagnosis was more common in those who were younger, of more junior rank, and serving in the Army; lower AFQT scores and previous mental health diagnosis were also positively associated. Patients with any mental health diagnosis had a higher postinjury heart rate and a lower postinjury diastolic

Table 1
Descriptive statistics by ICD-9 diagnosis, male battle-injured combatants, Operation Iraqi Freedom, September 2004–February 2005.

Characteristic	Total (n = 831)	Any mental health outcome			Posttraumatic stress disorder		
		Diagnosis + (n = 260)	Diagnosis − (n = 571)	P[a]	Diagnosis + (n = 141)	Diagnosis − (n = 690)	P[a]
Demographics							
Age, y (mean ± S.D.)	24.1 (5.3)	23.5 (4.5)	24.3 (5.6)	.02	23.6 (4.5)	24.2 (5.5)	.24
Rank, No. (%)				.01			.36
E1–E3	347 (41.8)	126 (48.5)	221 (38.7)		64 (45.4)	283 (41.0)	
E4–E6	352 (42.4)	104 (40.0)	248 (43.4)		61 (43.3)	291 (42.2)	
E6–E9	88 (10.6)	24 (9.2)	64 (11.2)		12 (8.5)	76 (11.0)	
WO/Officer	44 (5.3)	6 (2.3)	38 (6.7)		4 (2.8)	40 (5.8)	
Service, No. (%)				<.01			<.01
Army	158 (19.0)	87 (33.5)	71 (12.4)		51 (36.2)	107 (15.5)	
Marines	637 (76.7)	161 (61.9)	476 (83.4)		85 (60.3)	552 (80.0)	
Other/unknown	36 (4.3)	12 (4.6)	24 (4.2)		5 (3.6)	31 (4.5)	
Married, No. (%)	365 (43.9)	125 (48.1)	240 (42.0)	.10	75 (53.2)	290 (40.2)	.01
AFQT, score (mean ± S.D.)[†]	58.9 (18.9)	56.6 (18.4)	59.9 (19.1)	.02	54.3 (17.8)	59.8 (19.0)	<.01
Prior MH diagnosis, No. (%)	49 (5.9)	28 (10.8)	21 (3.7)	<.01	13 (9.2)	36 (5.2)	.07
Injury-specific, No. (%)							
Injury mechanism				<.01			.02
Improvised explosive device	343 (41.3)	105 (40.4)	238 (41.7)		52 (36.9)	291 (42.2)	
Grenade	56 (6.7)	18 (6.9)	38 (6.7)		11 (7.8)	45 (6.5)	
Mortar	68 (8.2)	17 (6.5)	51 (8.9)		10 (7.1)	58 (8.4)	
Blast, other	158 (19.0)	34 (13.1)	124 (21.7)		18 (12.8)	140 (20.3)	
Gunshot wound	146 (17.6)	69 (26.5)	77 (13.5)		38 (27.0)	108 (15.7)	
Fragment/shrapnel	43 (5.2)	12 (4.6)	31 (5.4)		10 (7.1)	33 (4.8)	
Other	17 (2.1)	5 (1.9)	12 (2.1)		2 (1.4)	15 (2.2)	
Facial injury	346 (41.6)	101 (38.9)	245 (42.9)	.27	48 (34.0)	298 (43.2)	.04
Injury Severity Score				<.01			<.01
Minor (1–3)	538 (64.7)	117 (45.0)	421 (73.7)		68 (48.2)	470 (68.1)	
Moderate (4–8)	155 (18.7)	63 (24.2)	92 (16.1)		28 (19.9)	127 (18.4)	
Serious (9–15)	93 (11.2)	52 (20.0)	41 (7.2)		30 (21.3)	63 (9.1)	
Severe (>15)	45 (5.4)	28 (10.8)	17 (3.0)		15 (10.6)	30 (4.4)	
Physiological (mean ± S.D.)[‡]							
Heart rate, bpm	86.5 (18.6)	89.0 (21.0)	85.3 (17.3)	.02	87.7 (20.9)	86.3 (18.2)	.47
Systolic BP, mm Hg	128.2 (16.3)	128.3 (18.7)	128.2 (15.1)	.92	128.2 (20.1)	128.3 (15.5)	.96
Diastolic BP, mm Hg	72.2 (13.2)	70.3 (13.5)	73.0 (13.0)	<.01	73.0 (14.4)	72.4 (13.0)	.30

ICD-9. International Classification of Diseases, 9th Revision; WO, warrant officer; AFQT, Armed Forces Qualification Test; MH, mental health; BP, blood pressure.
[a] Comparing diagnosis+ with diagnosis−.
[†] Due to missing data, n = 791.
[‡] Due to missing data, n = 726 for heart rate, n = 731 for systolic BP, and n = 725 for diastolic BP.

Table 2
Age-adjusted associations, physiological and injury-specific predictors, male battle-injured combatants ($n = 831$).

Characteristic	Diagnosis +/−			
	Any mental health outcome		Posttraumatic stress disorder	
	OR (95% CI)	P	OR (95% CI)	P
Injury-specific				
Injury severity		<.01		<.01
Minor	1.00		1.00	
Moderate	2.47 (1.69, 3.62)	<.01	1.52 (0.94, 2.47)	.09
Serious	4.62 (2.92, 7.31)	<.01	3.30 (2.00, 5.46)	<.01
Severe	5.68 (3.00, 10.76)	<.01	3.37 (1.72, 6.60)	<.01
Facial injury (yes/no)	0.84 (0.62, 1.13)	.24	0.67 (0.46, 0.99)	.04
Injury mechanism		<.01		<.01
Other	1.00		1.00	
Improvised explosive device	1.32 (0.95, 1.85)	.10	1.02 (0.67, 1.56)	.91
Gunshot wound	2.70 (1.79, 4.06)	<.01	2.02 (1.25, 3.24)	<.01
Physiological[a]				
Heart rate ≥ 95 (yes/no)	1.45 (1.03, 2.03)	.03[†]	1.15 (0.76, 1.76)	.51
Systolic blood pressure (mmHg)	1.00 (0.99, 1.01)	.90	1.00 (0.99, 1.01)	.95
Diastolic blood pressure (mm Hg)[‡]				
Minor injury	0.98 (0.96, 0.99)	.02	...	
Moderate injury	0.96 (0.93, 0.99)	.01	...	
Serious injury	1.02 (0.99, 1.06)	.15	...	
Severe injury	1.04 (1.00, 1.08)	.05	...	

OR, odds ratio; CI, confidence interval.
[a] Due to missing data, $n = 726$ for heart rate, $n = 731$ for systolic BP, and $n = 725$ for diastolic BP.
[†] P value > .10 after adjusting for injury severity.
[‡] Significant interaction between diastolic blood pressure and injury severity ($P < .01$), results presented by injury severity.

blood pressure. Injury mechanism and injury severity differed when comparing any mental health diagnosis with no mental health diagnosis; the highest rates of any mental health diagnosis were seen among those with moderate to severe injuries and those with gunshot wound injuries.

When comparing PTSD diagnosis and no diagnosis, the aforementioned associations with military service, AFQT score, injury severity, and injury mechanism remained whereas the associations with military rank, age, previous mental health diagnosis, heart rate, and diastolic blood pressure did not retain statistical significance. Diagnosis of PTSD was more common in those who were married and less likely in those who suffered a facial injury.

Injury severity was additionally associated with several variables (data not shown); patients in the Army suffered more-severe injuries than Marines; heart rate was significantly higher among severe injuries than minor, moderate, and serious injuries; systolic blood pressure was significantly lower among severe injuries compared with minor and moderate injuries; diastolic blood pressure was significantly lower among severe injuries than among minor, moderate, and serious injuries; and gunshot wounds were associated with more-severe injuries.

Those excluded from the analysis of physiological measures, because of either missing measurements or evidence of measurements taken more than 24 h postinjury, were more likely to have minor injuries and more likely to be Marines.

Results of age-adjusted logistic regression modelling for all physiological predictors (elevated heart rate, SBP, DBP) and injury-specific predictors (injury severity, injury mechanism, facial location) are shown in Table 2. Injury severity was significantly associated with diagnosis of any mental health outcome, with an approximately 2–6-fold greater risk in moderate, serious, and severe injuries compared with minor injuries. Serious and severe injuries had a 3-fold greater risk of PTSD diagnosis compared with minor injuries. Gunshot wounds conferred a 2.70 times greater risk (95% confidence interval [CI], 1.79–4.06) of diagnosis of any mental health outcome, and a 2.02 times greater risk (95% CI, 1.25–3.24) of PTSD diagnosis compared with other mechanisms. Facial injury was negatively associated with PTSD diagnosis ($p = 0.04$). Although elevated heart rate was associated with any mental health outcome ($p = 0.03$), after adjusting for injury severity the p value rose above the criterion level of .10 and the variable was restricted from further analysis.

A test for interaction between injury severity and diastolic blood pressure was significant for any mental health outcome ($p < 0.01$), but not PTSD. Table 2 presents the details of the interaction. Among minor and moderate injuries, postinjury diastolic blood pressure was inversely associated with any mental health outcome. Conversely, among severe injuries, increasing diastolic blood pressure was positively associated ($p = 0.05$) with any mental health outcome.

Table 3 shows the final injury-specific predictive logistic regression model for any mental health outcome and PTSD. None of the covariates assessed met the criteria for confounding. The final model included age, injury severity, injury mechanism, and, for PTSD diagnosis only, facial injury.

Compared with minor injury, those with moderate, serious, and severe injury were 2.37 (95% CI, 1.61–3.48), 4.07 (95% CI, 2.55–6.50), and 5.22 (95% CI, 2.74–9.96) times more likely to be diagnosed with any mental health outcome, respectively. Similar results were found for PTSD diagnosis: those with serious and severe injury were 3.03 (95% CI, 1.81–5.08) and 3.21 (95% CI, 1.62–6.33) times more likely to receive a PTSD diagnosis, respectively. In comparison with other mechanisms of injury, those injured by gunshot wound were 2.07 (95% CI, 1.35–3.19) times more likely to be diagnosed with any mental health outcome; a similar association was not found with PTSD. Facial injury was not associated with PTSD diagnosis.

With respect to the sensitivity analysis, in the first year of follow-up, 96 (11.6%) patients were discharged without a mental health diagnosis. An additional 88 (10.6%) were discharged after the first year of follow-up. Those lost to follow-up were younger, of more junior rank, were less likely to be married, and were more likely to be Marines. All associations were consistent throughout the sensitivity analysis.

Table 3
Final injury-specific logistic regression model, male battle-injured combatants ($n = 831$).

Characteristic	Diagnosis +/−			
	Any mental health outcome		Posttraumatic stress disorder	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Age, y	0.97 (0.94, 1.00)	.04	0.98 (0.95, 1.02)	.34
Injury severity		<.01		<.01
Minor	1.00		1.00	
Moderate	2.37 (1.61, 3.48)	<.01	1.46 (0.90, 2.37)	.13
Serious	4.07 (2.55, 6.50)	<.01	3.03 (1.81, 5.08)	<.01
Severe	5.22 (2.74, 9.96)	<.01	3.21 (1.62, 6.33)	<.01
Facial injury (yes/no)	...		0.75 (0.49, 1.15)	.18
Injury mechanism		<.01		.26
Other	1.00		1.00	
Improvised explosive device	1.21 (0.85, 1.71)	.29	1.01 (0.65, 1.56)	.98
Gunshot wound	2.07 (1.35, 3.19)	<.01	1.49 (0.90, 2.46)	.12

OR, odds ratio; CI, confidence interval.

Discussion

Physical injury among military combat veterans is associated with later psychological morbidity, such as PTSD. The present study found positive associations between injury severity and mental health diagnosis, including PTSD, among a population of battle-injured male combatants. Gunshot wounds and diastolic blood pressure were predictive of any mental health outcome, but not of PTSD. No association was found between postinjury heart rate and subsequent mental health outcome after adjusting for injury severity. Degree of combat exposure, which was not measured in the present study, and differences in medical utilization may have influenced the results.

Although the literature generally supports that physical injury is a risk factor for mental health outcome, less evidence exists for objective injury severity. One study found that an ISS of 11 and above was predictive of development of PTSD among motor vehicle accident survivors.[26] An earlier study demonstrated a significantly higher ISS among those motor vehicle accident survivors who developed PTSD than those who did not develop PTSD.[17] Both of these studies, however, had study populations with a higher overall ISS than the current study. In contrast to the aforementioned studies, one study found that the subjective measure of perceived threat to life was a much better predictor of PTSD following traumatic injury than was ISS.[29]

To our knowledge, the relationship between injury mechanism and mental health outcome has not been previously examined within a military combat population. Among a population of orthopaedic injuries, Starr et al. found a greater percentage of PTSD among those injured in motor vehicle accidents compared with falls.[51] Holbrook et al. found that later PTSD development was predicted by penetrating injuries and assaults, relative to other mechanisms of injury.[29] The only study to directly address gunshot wounds was among a paediatric population; gunshot wounds were significantly associated with development of PTSD.[21]

The null finding between heart rate and PTSD development is not consistent with much of the existing literature. Specifically, Zatzick et al. found a significant predictive association between heart rate assessed in the emergency room and subsequent PTSD development; this study also used the same cut-off for elevated heart rate as the current study (95 bpm).[58] The study population, however, was very different from the current study, with more than one-third female participants, inclusion of intentional injuries, higher injury severity, and high frequency of drug and alcohol abuse. An earlier study by Shalev et al. found similar results in a much different study population of mildly injured patients, excluding those with head injury and past/present substance abuse or psychosis; those who developed PTSD had significantly higher heart rates both in the emergency room and 1 week later.[50] The lack of finding an association between heart rate and PTSD in the present study may be due to the nature of the study population. It is possible that the stress response of combat forces in general is very different from the civilian population. Alternatively, heart rate measurements may have been inaccurate as a result of differing methods of ascertainment in the field.

Multiple theories can explain the primary findings of the present study that injury severity and mechanism, as well as postinjury diastolic blood pressure, were associated with mental health diagnoses. Mayou and Bryant found that severity of injury substantially predicted self-report of physical recovery 3 months postinjury.[40] Thus, increasing injury severity may be associated with greater risk of disability, which has been shown in multiple studies to be associated with development of PTSD and other psychological symptoms.[3,41,42] Grieger et al. found that early severity of physical problems, measured subjectively, was associated with later development of both PTSD and depression.[23] Injury severity may also be related to increasing degree of combat exposure, thus explaining the positive association between injury severity and mental health diagnosis.

Another theory regarding injury severity is that of increased medical utilization. The primary outcomes of interest are ascertained via a database of medical encounters. Those with more-severe injuries may have increased visits to medical facilities, which may increase the chances of that individual being referred for mental health evaluation. This theory is supported by the fact that, in the current study, increasing injury severity is strongly associated with evacuation to higher level of care, which may lead to greater detection of mental health problems. This may indicate the need for targeted mental health screening for minor battle injuries and those not evacuated to higher levels of care. The association with gunshot wounds may be a result of higher battle intensity, assuming those presenting with gunshot wounds may be more likely to be consistently involved in close combat. This greater exposure to close combat can lead to other psychological stressors, such as witnessing the death of friends, civilians, and enemy soldiers. Another theory is that there may be greater detail remembered with the trauma; those with gunshot wounds may be more likely to visualise their attacker, which could lead to a more-severe traumatic memory.

To our knowledge, the association found with diastolic blood pressure and any mental health outcome, and its significant interaction with injury severity, is a unique finding. It is possible this association may be a result of blood pressure-altering

medications given at the point of injury. Further research is needed to replicate this finding.

There are study limitations that warrant mention. Multiple variables that may have affected the results were absent from the analysis, including combat exposure, blood loss, and medications provided. Regarding the study population, the data were collected from Navy-Marine Corps medical treatment facilities only, thus a preponderance of injuries were among Marines; injuries treated by forward-deployed Army facilities were not represented. The primary outcome measures used were ascertained from an electronic database that tracks medical encounters; therefore, to be classified with the outcome, one would have to seek treatment first. Previous studies in the area of physical injury and mental health have, for the most part, utilised survey instruments with all participants to ascertain symptoms. Also, there is a potential for misdiagnosis in some cases. However, all diagnoses reported in this study come from credentialed providers at military treatment facilities and government-reimbursed private clinics. Furthermore, the U.S. Department of Defense requires monthly audits and medical coding accuracy reports to ensure quality control throughout the military healthcare system. Therefore, though we were unable actually affirm whether the diagnostic criteria for outcomes such as PTSD were met, there is no reason to suspect systematic misclassification bias. Another limitation of using medical encounter data is that many individuals exhibiting symptoms may be missed because of an aversion to seeking treatment. Additionally, those seeking treatment may be the most-severe cases. Toward the end of the follow-up for this study, data from CHAMPS may not have been fully updated because of a lag in entering ICD-9 codes. To account for the lag, the analysis was repeated including only outcomes diagnosed through August 2006, and similar results were found. Another limitation was the high rate of loss to follow-up via military discharge and the inability of CHAMPS to track personnel postdischarge.

The primary strength of the current study is that it is one of few military-specific population-based studies to examine the relationship between physical injury and psychological morbidity. A wide range of injury severity is included in the current study, compared with a recent study that examined PTSD and depression only among severely injured combatants.[23] Additionally, the injury-specific information, including mechanism and postinjury physiological measures, to our knowledge has not been thoroughly documented within a military combat population. Because this information is collected at baseline, issues such as recall bias are avoided. The use and high matching rate of the CHAMPS database allowed for assessment of demographic variables, as well as previous mental health diagnoses.

Conclusion

Diagnosis of PTSD and any mental health outcome was predicted by injury severity among a population of male, injured military combatants. Additionally, gunshot wounds and diastolic blood pressure predicted diagnosis of any mental health outcome. The results of this study may indicate a need for greater mental health screening of specific injured subgroups of combat personnel. Future studies should attempt to quantify combat exposure and should incorporate data from the Department of Veterans Affairs in order to track those discharged because of their injury. Physical injuries are a reality of war and further understanding of their relationship with psychological morbidity is essential.

Conflict of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

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